MAP No. 105-F-8,9

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TYPE OF WORK: Geol. Thesis

REPORT FILED UNDER	University of British Columbia	DOCUMENT NO.	061738
DATE PERFORMED	1977	DATE FILED:	June 22, 1978.
LOCATION – LAT.	61° 30' N	AREA:	Seagull Creek, Yukon.
LONG.	132° 25' W		
CLAIM NO.	GUANO 1-22 GUAYES 23-30		
VALUE $			
WORK DONE BY	F.J. Chronic and C.I. Godwin (U of BC)		
WORK DONE FOR	Indian & Northern Affairs (university research contract)		
REMARKS	Geological description of a skarn zone carrying concentrations of rare earth elements up to 50 times greater than in normal sedimentary rocks.		

RARE EARTH ELEMENTS IN THE GUANO SKARN PROPERTY

PELLY MOUNTAINS, YUKON TERRITORY

By: Chronic, F.J., and C.I. Godwin, Department of Geological Sciences, The University of British Columbia, Vancouver, B.C., V6T 1W5

GUANO CLAIMS (Guano 1-22 and Guayes 23-30)
Ukon Joint Venture, managed by Archer
Cathro and Associates, Ltd.
Vancouver, B.C.

Uranium, REE
105 F/8, 9
(61°30'N, 132°25'W)

References: Deer et al. (1966); Goldberg et al. (1963); Haskin et al. (1968); Haskin & Haskin (1966); Herrmann (1968, 1971); Moeller (1963), Nance & Taylor (1976); Overstreet (1967); Rose (1976); Sinclair (1976); Tempelman-Kluit (1977); Towell et al. (1965); Whittle (1960).

ABSTRACT

The Guano property, in the St. Cyr Range of the Pelly Mountains, covers a skarn zone which is about 300 meters wide (about 70 meters thick) and at least 1100 meters long. Contact metasomatism of Silurian to Devonian Pelly-Cassiar Platform carbonates formed the skarn adjacent to a hornblende-rich syenitic stock related to the Seagull Creek volcanic episode of probable Mississippian age.

Sporadic areas within the skarn contain concentrations of rare earth elements (REE) up to 50 times greater than those seen in normal sedimentary rocks. Twenty-one Guano property samples analyzed for REE by neutron activation can be tentatively divided into three groups with extreme, high, and low REE content by using probability graphs and by picking out the few extreme values. Average Guano REE patterns have similarities to both standard sedimentary and granitic patterns. These reveal a crustal origin for REE, but are inconclusive in distinguishing between a sedimentary (original placer) or an igneous source but the syenite sample analyzed, although containing extremely high total REE, has a REE pattern significantly different from the rest of the Guano rocks. The origin of the REF in the Guano skarn must be defined before the mechanism responsible for its concentration, whether sedimentary or igneous, can be understood.

INTRODUCTION

The Guano skarn property is in the Pelly Mountains of the Yukon Territory about fifty kilometers south of Ross River. Access to the property is by helicopter only. The major skarn crops out on the side of a north-facing cirque, well above timberline. Sea-Gull Creek, the nearest river, is the inspiration for naming the property "Guano." The Guano skarn formed at the margin of a (Mississippian?) syenitic intrusion that cuts a middle Paleozoic (Silurian to Devonian) carbonate sequence within the Pelly-Cassiar Platform (Tempelman-Kluit, 1977).

Prospecting for uranium in the skarn, spurred on by small, sporadic highly radioactive areas, disclosed the presence of rare earth elements (REE) in much greater than normal quantities. Because the Guano property was the first documented occurrence of a high rare earth element concentration in the Yukon Territory, and one of only a few known rare earth element bearing skarns (Mary Kathleen in Australia is another, Whittle, 1960), further studies of the prospect seemed warranted.

Two analytical studies of REE undertaken on rocks from the Guano skarn were 1) a qualitative field test for REE, used during mapping, and 2) neutron activation analyses, the main subject of this paper. Petrological studies are still in progress and will only be touched on here. REE studies of the Guano skarn property were made with two goals in mind: 1) to document the potential for a mineable deposit in the skarn and 2) to define the origin of the occurrence. One unexpected result of the studies was a clear indication of inaccuracy for the field test.

GEOLOGY OF THE GUANO SKARN

Geology of an area including the Guano Skarn is shown in Figure 1. Stratified rocks in the area consist of a series of Silurian to Devonian carbonate rocks, intruded by Mississippian syenite, in fault contact with Ordovician phyllite to the east. A reef environment prevailed during formation of the carbonate rocks as shown by abundant crinoid stems, but a minor clastic component is represented by shaly beds and thin fine-grained orthoquartzites.

As a result of syenite intrusion, the carbonate rocks have been recrystallized and some have been metasomatized to form skarn. Generalized distribution of skarn zones, shown on Figure 1, is based on field observations.

ROSE'S FIELD TEST FOR REE

Rose's (1976) field test for rare earth elements was used extensively while mapping. Delineation of a deposit, if present, should have been realized according to the REE concentration sensitivity of the test as defined by Rose. However, no general area of rare earth element enrichment was established using it. Field test results were quite unsystemmatic. Variations were common from place to place for one rock type. More positive tests were obtained from some of the apparently unaltered sediments than for most of the skarn rocks. This led to serious doubts about their validity. Several neutron activation analysis samples were chosen to check these tests, and results of the two are compared in the last two columns of Table 1. From this table the field test is apparently invalid for these rocks. N6, the syenite sample, is one of four REE-rich rocks, yet it tested only weakly positive in the field. Ø10, a carbonate-rich skarn rock, has one of the lower total REE contents, yet it tested strongly positive.

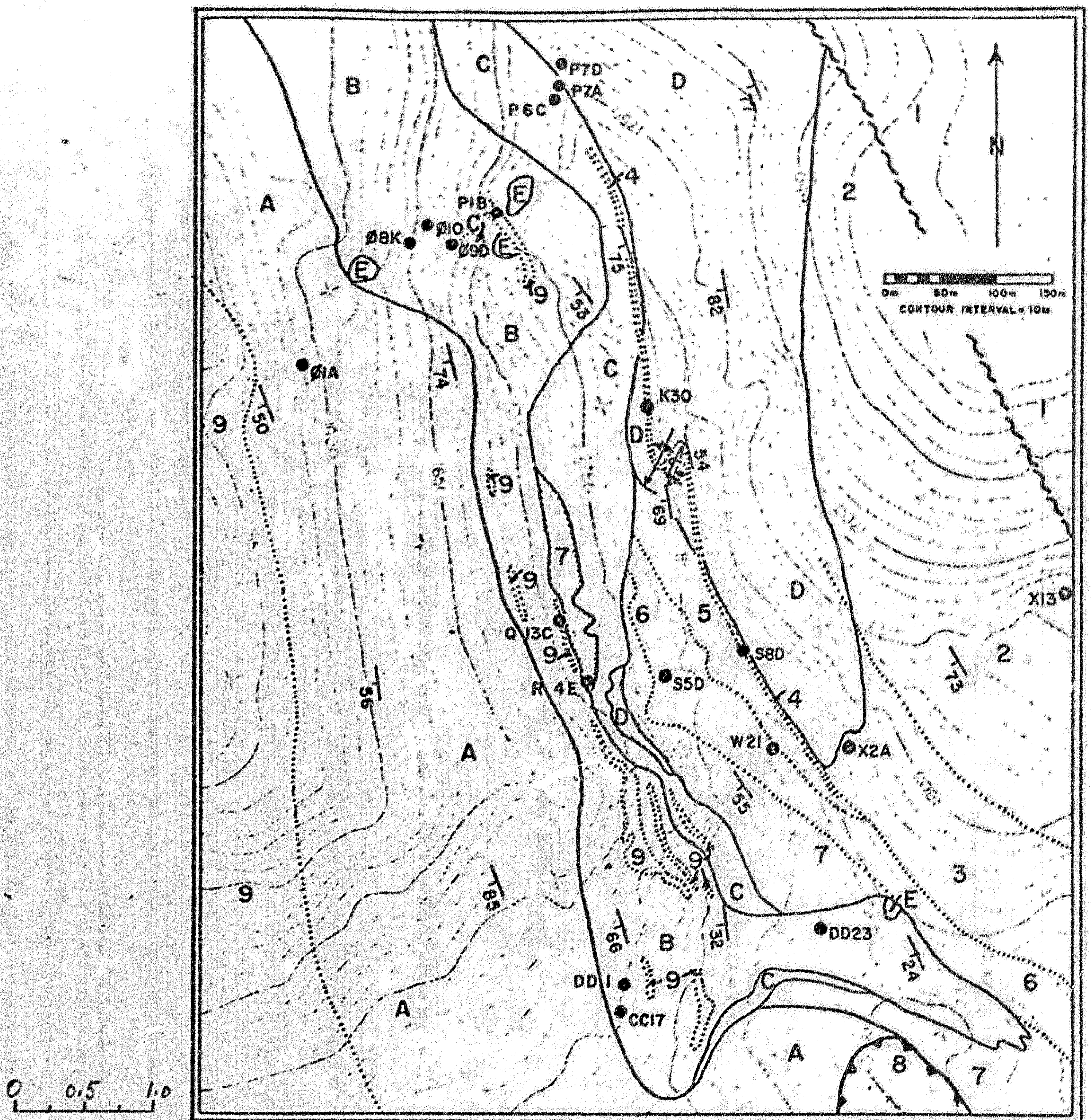

Figure 1: Geology and Sample Locations, Guano Group, Pelly Mountains, Y.T. METASOMATIC ROCKS: A=hornfels, B=dark green carbonate skarn, C=phlogopite-calcite skarn, D=ophicalcite, E=brecciated and calcite cemented skarn. SEDIMENTARY ROCKS: Ordovician: 1=black pyritic shale; Devonian to Silurian: 2=grey shaly limestone, 3=white crinoidal dolomite, 4=white to brown massive quartzite, 5=tan shaly limestone, 6=black fossiliferous dolomite, 7-white limestone and dolomite; Mississippian: 8=black shale. IGNEOUS ROCKS: 9=syenite and related intrusive rocks. SYMBOLS: large dots represent REE analysis sample points; solid contacts are metamorphic zone boundaries; dotted contacts are sedimentary and igneous contacts; structural symbols are standard.

TABLE 1

RARE EARTH ELEMENT VALUES IN PPM, GUANO PROPERTY

SAMPLE		^{57}La	^{58}Ce	^{60}Nd	^{62}Sm	^{63}Eu	^{65}Tb	^{66}Dy	^{70}Yb	^{71}Lu	TOTAL	F. T.
K30	FSV	35.5	58.	22.	2.34	0.29	0.3	1.5	3.4	0.54	124	+++
M21	SKN	37.	79.	28.	5.89	0.35	0.9	10.6	9.3	1.07	172	+++
N6	SYN	1860.	295.	140.	153.	9.0	1.1	63.0	42.6	0.33	2564	+
Ø1A	HFL	3.9	9.4	7.	0.56	0.2	0.1	0.4	0.25	0.06	16	none
Ø8K	CBS	6.[illegible]	12.	5.	1.36	0.37	0.2	1.6	0.8	0.10	28	+++
Ø9D	SKN	45.	53.	16.	1.60	0.33	0.2	1.1	1.3	0.16	119	+++
Ø10	CBS	64 5	121.	64.	10.1	0.79	0.8	6.4	8.0	1.25	277	++
P1B	QZV	12.2	11.	27.	0.45	0.21	0.1	0.6	0.4	0.05	52	+++
P6C	PCB	4460.	6150.	3300.	450.	50.9	61.	394.	230.	16.0	15110	+++
P7A	SRP	69.2	123.	11.	16.3	5.1	1.4	11.3	6.8	0.67	245	+++
P7D	ØPH	80.6	23.	48.	166.	4.2	3.5	281.	222.	2.26	831	+++
Q13C	CSK	6.6	15.	4.	2.26	0.30	0.1	2.4	1.3	0.13	32	+++
R4E	DØL	4.4	12.	6.	0.89	0.44	0.1	0.9	1.1	0.15	26	+
S5D	BKV	296.	336.	53.	8.35	3.1	1.8	22.9	31.6	2.93	756	++
S8D	QZT	117.	165.	96.	15.4	7.6	1.4	12.3	10.8	1.16	427	-
W21	CDØ	47.5	214.	120.	7.42	2.0	1.2	9.4	4.0	0.61	406	+++
X2A	ØØD	30.	53.	17.	4.85	0.42	0.5	3.2	2.3	0.21	111	+++
X13A	SELS	11.2	31.	5.	8.25	0.93	0.9	7.8	4.3	0.36	70	+++
CC17	ZV	3.5	4.5	4.	0.50	0.19	0.1	0.7	0.3	0.07	14	-
DD1	DIS	30.9	65.	84.	8.97	0.93	0.8	6.6	4.9	0.48	203	-
DD23	DSK	4980.	8070.	4300.	930.	113.	170.	991.	790.	71.6	20420	+++
STD	DEV	±0.5	±1.	±2.	±0.04	±0.07	±0.1	±0.3	±0.2	±0.03		

La	Lanthanum	Sm	Samarium	Dy	Dysprosium
Ce	Cerium	Eu	Europium	Yb	Ytterbium
Nd	Neodymium	Tb	Terbium	Lu	Lutetium

NEUTRON ACTIVATION ANALYSES FOR RARE EARTH ELEMENTS

Twenty-one rock samples from the Guano property were each analyzed for nine rare earth elements (La, Ce, Nd, Sm, Eu, Tb, Dy, Yb, and Lu) by neutron activation analysis. R.G.V. Hancock at the SLOWPOKE Reactor, University of Toronto, analyzed the rocks. Sample locations are shown on Figure 1.

Rocks selected for analyses represent four syenite dykes from within the skarn, one syenite from the main intrusive body, ten skarn rocks and six sedimentary rocks. These were chosen to 1) check the accuracy of Rose's field test for REE, 2) compare sediments and syenite as possible sources for REE in the skarn, 3) define REE contents in the different skarn types, and 4) to provide a reasonably comprehensive geographic distribution.

Analytical results are given in Table 1. Accuracy for Nd and Tb values is approximately 20%. For all other elements, the last row of numbers is the counting statistical standard deviation. Exceptions are samples N6, P6C, P7D, and DD23, the four richest samples, for which the counting statistical errors are approximately 1% of the analytical values shown. The second to last column, "TOTAL," is the sum of only those REE analyzed. The last column is the field test data. These are qualitatively marked: - for not detected, + for faintly positive, ++ for definitely positive, or +++ for extremely positive.

The raw data of Table 1 displays a variation of three orders of magnitude in the amount of REE in different samples. Four, and possibly five samples (N6 syenite, P6C phlogopite-calcite skarn, P7D ophicalcite, DD23 diopside skarn, and possibly S5D dyke rock), are unusally high in REE content. These samples neither occur close to one another, nor are they of the same rock type. P6C and S5D are the only samples in which anomalous radioactivity was detected by use of a scintillometer in the field.

Two probability graphs (the four dyke rocks and five samples with extreme values are omitted) are shown in Figure 2. The plot for ytterbium scatters about a straight line. Terbium values plot in a curved pattern that suggests the presence of two discrete populations (Sinclair, 1976),

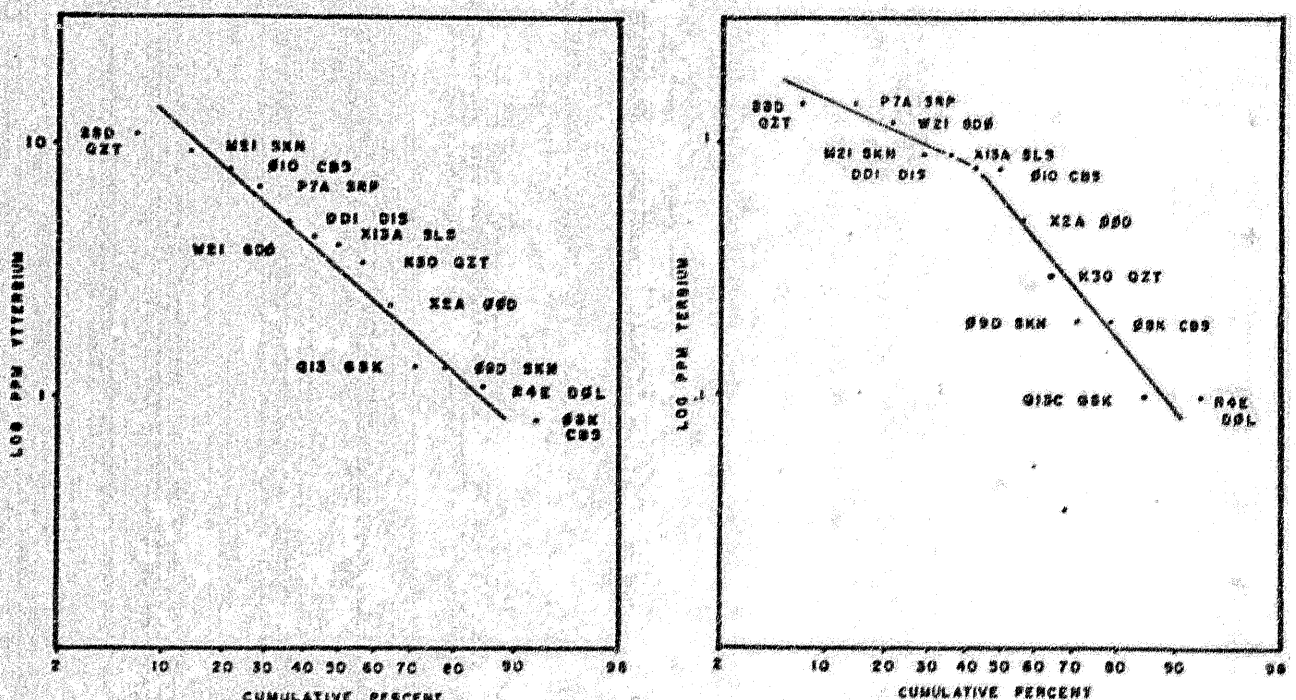

Figure 2: Probability Graphs for Ytterbium (Left) and Terbium (Right). Ytterbium approximates a single population. Terbium is best represented by two populations.

although data are limited. Probability plots for Tb, Eu, Sm, Ce, and La all indicate the likely existence of two distinct populations. There is no indication of a correlation between the two populations and rock type. Data thus were divided into three tentative groups named: 1) extreme, 2) high, and 3) low, according to their relative REE contents. The latter two groups were defined from the probability graphs. Samples in each population by each of the above groups are in Table 2. Table 3 shows the mean and standard deviation for each group.

TABLE 2

STATISTICAL REE SAMPLE GROUPS, GUANO PROPERTY

GROUP	SAMPLE NUMBER		ROCK TYPE
1. Extreme	N6	SYN	syenite
	P6C	PCB	phlogopite-calcite skarn
	P7D	ØPH	ophicalcite
	DD23	DSK	diopside-calcite skarn
2. High	S8D	QZT	brown talcose quartzite
	P7A	SRP	serpentine
	Ø10	SKN	skarn
	W21	GDØ	gray fossiliferous dolomite
	M21	SKN	skarn
	DD1	DSK	diopside skarn
	X2A	ØØD	white oolitic dolomite
	X13A	SLS	gray shaly limestone
3. Low	Q13C	GSK	garnet skarn
	R4E	DØL	gray dolomite marble
	Ø8K	CBS	calcite-tremolite skarn
	Ø1A	HFL	hornfels

Values of the average samples for each of the three groups were compared to those of chondrites, post-Archean Australian sediments, and granitic rocks. This was done by dividing the mode for each REE value of each group by chondritic, sedimentary, and granitic values. Values used for normalizing are in Table 4. Normalized patterns are plotted in Figure 3. Patterns for all groups in each graph are parallel within the margin of error. Their main difference is simply magnitude. The chondrite-normalized groups show a relative enrichment in light REE. The sediment and granite-normalized groups show patterns which are essentially horizontal lines. An horizontal line means that the patterns for the normalized and normalizing values are similar. The similarities will be discussed in more detail later. Comparison of the different magnitudes can be made from the values listed in Table 5. This table shows that the extremely high group contains about fifty times the normal REE content of sedimentary rocks, the high group about three halves as much, and the low group only one sixth as much. These differences in magnitude, along with the lack of data on which to define different populations, led to the following approach to data analysis.

TABLE 3

MEANS AND STANDARD DEVIATIONS FOR 1) EXTREME, 2) HIGH, AND 3) LOW REE GROUPS FROM GUANO PROPERTY ROCK SAMPLES

1. Extreme Group $n_1 = 4$

	La	Ce	Nd	Sm	Eu	Tb	Dy	Yb	Lu
$\bar{X}_1$	2,845	2,135	1,947	425	44.3	58.9	432	321	22.6
s_1	2,293	3,959	2,179	364	50.4	79.1	397	324	33.4

2. High Group $n_2 = 8$

	La	Ce	Nd	Sm	Eu	Tb	Dy	Yb	Lu
$\bar{X}_2$	50.9	106.4	79.8	9.65	2.26	1.0	8.5	6.3	.73
s_2	32.7	61.5	58.5	4.18	2.66	.3	3.0	2.9	.39

3. Low Group $n_3 = 4$

	La	Ce	Nd	Sm	Eu	Tb	Dy	Yb	Lu
$\bar{X}_3$	5.4	12.1	5.5	1.27	.32	.13	1.33	0.9	0.11
s_3	1.4	2.3	1.3	.74	.10	.05	.87	.5	.04

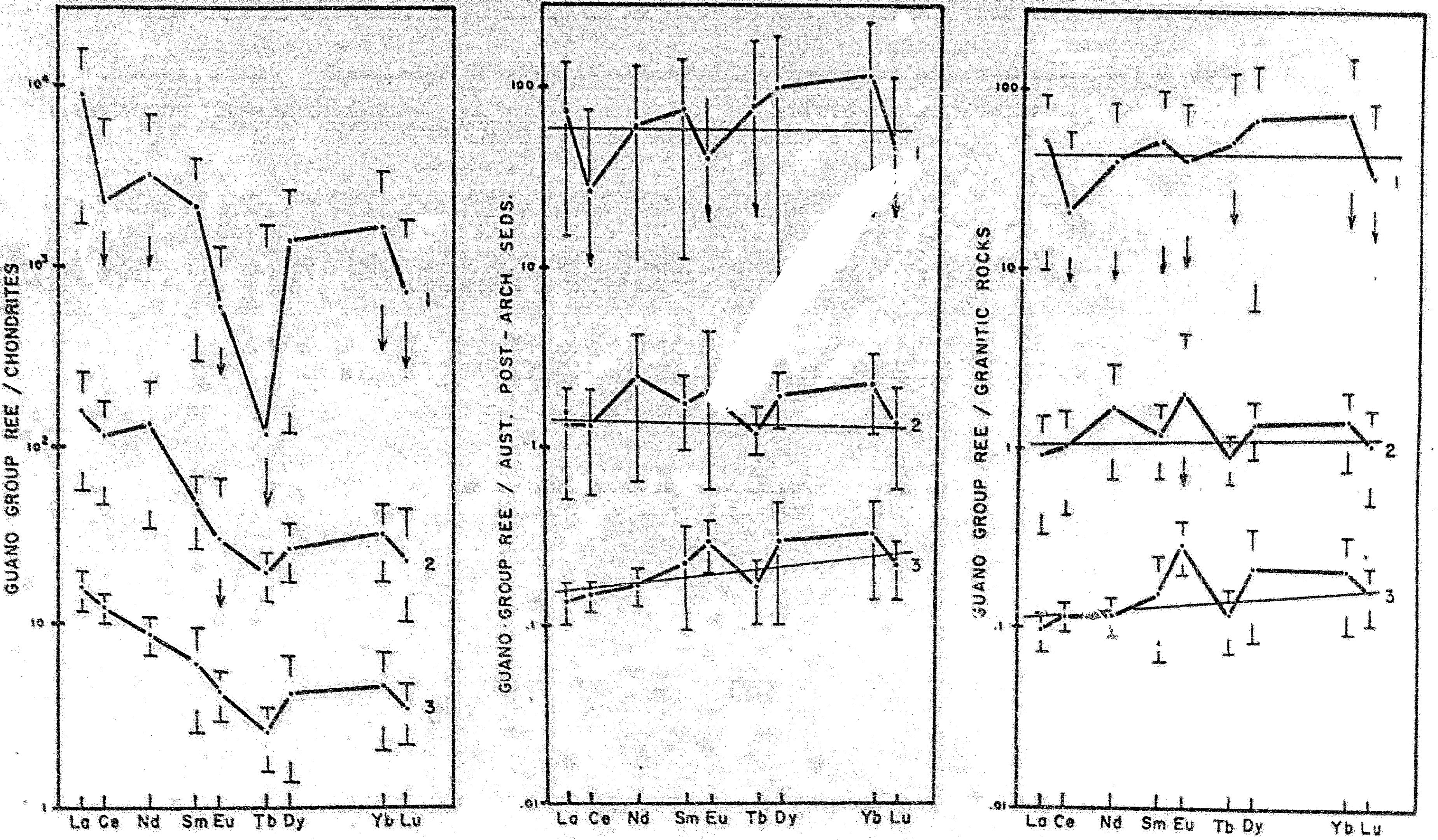

Figure 3. REE Patterns for Guano Rock Groups Normalized to 1) chondrites (left), 2) post-Archean Australian sediments (center) and 3) granitic rocks (right). Error bars represnet S_n/normalizing value. Error bars with arrows extend off the graph.

TABLE 4

STANDARD REE VALUES USED FOR NORMALIZING

ELEMENT	Average of 22 Chondrites Herrmann, 1971	Average of Granitic Rocks Haskin et al.,1968	Average of 40 North American Shales Haskin & Haskin, 1966	Pacific Ocean Water 100 m. deep Goldberg et al., 1963	Average of Post-Arch. Austr. Seds. Nance & Taylor, 1976
La	.32	55.	32.	.0029	38.
Ce	.94	104.	73.	.0013	80.
Nd	.60	47.	33.	.0023	32.
Sm	.20	8.	5.7	.00042	5.6
Eu	.073	1.1	1.24	.000114	1.1
Tb	.050	1.1	.85	-	.77
Dy	.31	6.2	-	.00073	4.4
Yb	.19	4.3	3.1	.00052	2.8
Lu	.031	.68	.48	.00012	.50

TABLE 5

AVERAGE TOTAL REE FOR GUANO PROPERTY ROCKS COMPARED TO AUSTRALIAN POST-ARCHEAN SEDIMENTS, A ROUGH ESTIMATE OF AVERAGE CRUSTAL VALUES

ROCK TYPE	AVERAGE TOTAL OF 9 REE
Australian Post-Archean Sediments	165 ppm
Guano Group 1. Extreme	8,230 ppm
Guano Group 2. High	266 ppm
Guano Group 3. Low	27 ppm

Parallelism of REE patterns for different populations implies that the only difference among them is one of magnitude. If the magnitude difference can be removed the patterns for all samples should be essentially the same, and could be averaged and used for interpretation. To remove the magnitude factor, the REE values for each sample were divided by the La value for each sample (cf. Haskin et al., 1966). This meant that for all samples La would equal 1. Points analyzed (except the dykes, syenite, and P7D which was found to be anomalous) were treated in this manner; the three previous population divisions were ignored. The mean for each element from this set of numbers was used for final analysis and interpretation. Means and standard deviations for this group of numbers are in Table 6. Since these REE values have been reduced to ratios, only

TABLE 6

MEANS AND STANDARD DEVIATIONS FOR LA-NORMALIZED REE VALUES, GUANO SKARN PROPERTY

	La	Ce	Nd	Sm	Eu	Tb	Dy	Yb	Lu
$\bar{X}$	1	1.93	.947	.148	.033	.019	.159	.123	.015
s	-	.85	.601	.073	.028	.013	.098	.127	.017

the shapes of their patterns can be compared to other REE patterns. To compare absolute amounts, the three previously designated populations or original raw data must be used.

INTERPRETATION OF REE DATA FROM THE GUANO SKARN

It was hoped that evaluation of data would provide some insight into the source of REE in the skarn. However, results were somewhat ambiguous.

Guano area rocks were compared to chondritic meteorites, two sets of Paleozoic sediments, sea water, granitic rocks, and the Guano syenite (Standard values are in Table 4). The standard values were first divided by their La content, as was done for the Guano area rocks. All information thus is at a comparable scale, making relative differences easily visible. Next, patterns for Guano rocks, Paleozoic sediments, sea water, and granitic rocks were all normalized to chondritic values. Patterns are presented on Figure 4.

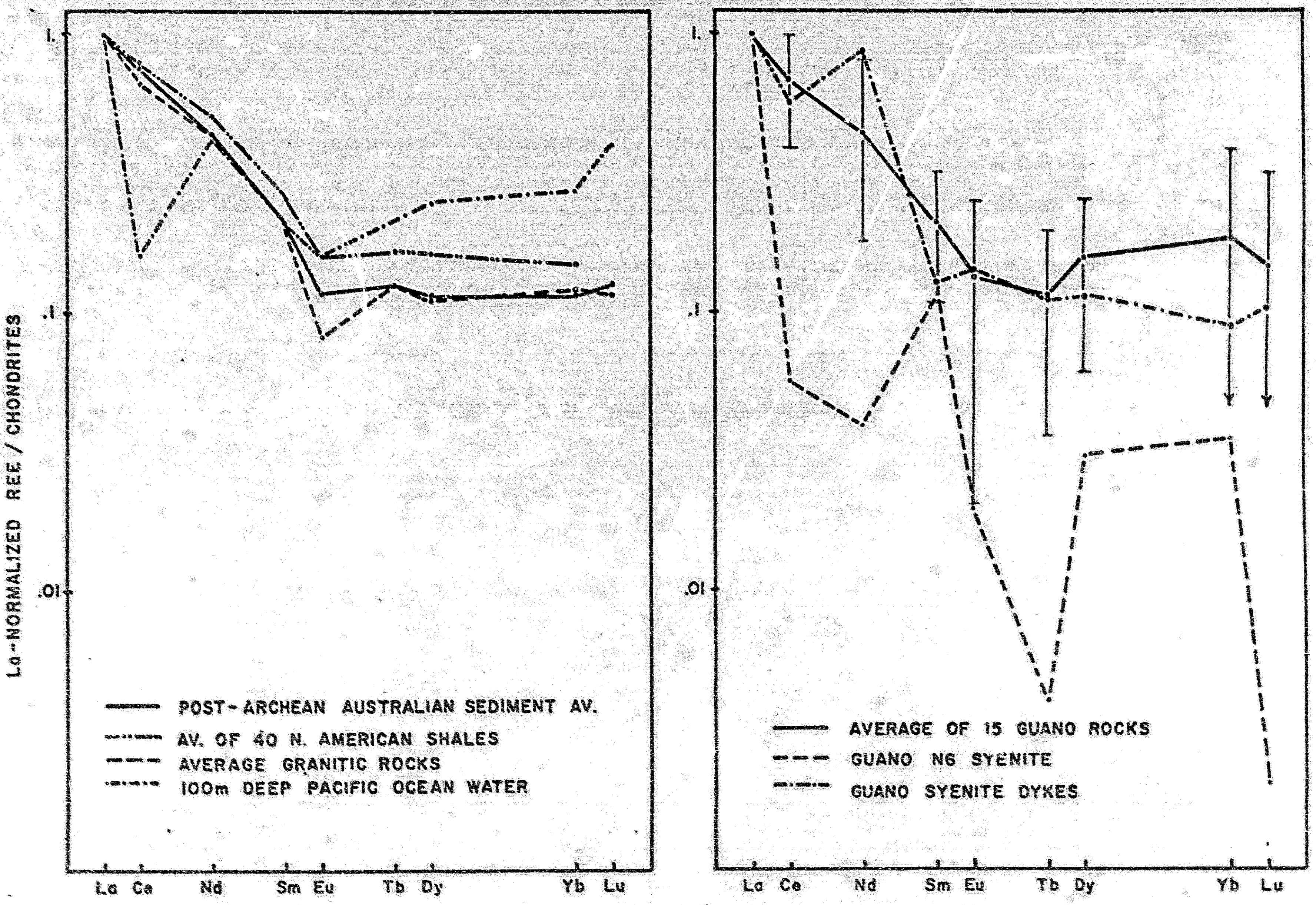

Figure 4: REE Patterns Normalized to La and Chrondrites. Standard reference materials (Table 4) are on left, and Guano data (Table 1) are on the right.

There is a remarkable similarity between the average Guano area rocks and the sedimentary and granitic patterns, confirming a crustal affinity for Guano REE. Standard granitic rocks and average Guano rocks share a similar La high which the two shale standards do not show, suggesting an intrusive origin for REE. Only the granitic rocks, however, have a relative europium depletion. The Guano average rocks do not have the pronounced Ce depletion seen in sea water. Guano rocks show relatively high heavy REE patterns compared to the rest of the rocks, suggesting that during their history they were either enriched in heavy REE or less enriched in light REE relative to normal crustal rocks.

Only one syenite sample from the Guano area was analyzed. It has a pattern which is significantly different from the average Guano rock and from normal crustal rocks. It shows relative enrichment in La, Sm, Dy, and Yb, and depletion in Eu, Tb, and Lu, which is not seen in the Guano average. The relatively high Dy and Tb of the Guano average rocks, however, might be a reflection of the syenite pattern.

Syenite dykes within the skarn have patterns similar to those of the Guano norm, but their total REE content is much lower. The difference between them and the N6 syenite sample is striking.

It is impossible to pinpoint a source for the REE in the Guano skarn and related rocks using only this analytical information. A closer look at the geology and petrology of the area, however, sheds some light on REE mineralization controls. Possibilities of a sedimentary source and of a syemitic source are examined below in light of the geology on the property.

REE could be derived from sedimentary rocks either by leaching very large volumes of rock or by the original existence of a REE-rich placer deposit. Leaching of a large area of normal sediments to form a concentration of REE In the skarn is unlikely, even though all carbonates in the area have been recrystallized. This is true for several reasons: 1) there is no evidence in the sediments for extensive leaching or of original REE-bearing minerals, 2) if leaching from limy rocks had taken place, a negative Ce anomaly reflecting the one in sea water would be expected (Goldberg et al., 1963), and 3) REE form extremely strong bonds and are not easily brought into solution (Moeller, 1963). This leaves an original placer deposit as the only possible sedimentary source for REE.

Placer deposits of REE minerals are not uncommon (Overstreet, 1967) and an original placer deposit of heavy REE minerals associated with the carbonate sequence quartzites, later altered by skarn formation, cannot be ruled out. The original nature of the heavily skarn-altered rocks can only be determined within certain limits: they were bedded, fine-grained, and contained carbonate, some iron, and some pelitic material. REE patterns are not constant in individual minerals, so they cannot be used to define an original placer material.

Geologically, a derivation for REE-bearing skarn-forming solutions from the syenite seems likely. The syenite sample (N6) analyzed was altered and might not represent the original syenite REE pattern. Syenite dykes in the skarn which were analyzed for REE have patterns similar to the Guano average, although they contain low total REE (Figure 4). Late purple fluorite-rich veins occur in both the syenite and the skarn, although they are not common in either. These veins contain higher than average amounts of REE and are markedly radioactive. REE are known (Mineyev, 1963) to form fluoride complexes in the late magmatic stages of intrusive episodes. Late alkalic phases of volcanic (Herrmann, 1968) and intrusive igneous complexes (Towell et al., 1965) contain several times more total REE than their cogenetic basaltic - gabbroic members. Thus, the Guano syenite, if an alkalic member of an igneous (Seagull Creek?) episode, should contain greater than average amounts of REE.

In one thin section of a syenite dyke, two generations of probable allanite, $(Ca,Ce)_2(Fe^{2},Fe^{3})Al_2O \cdot OH(Si_2O_7)(SiO_4)$ (Deer et al., 1966), are present. One is older, partially corroded, and one is younger, in late epidote-rich veinlets. In many skarn rocks, interstitial black isotropic material is the only possible REE mineral, as yet unidentified.

The four rocks with extremely high REE contents are the syenite, the coarse-grained phlogopite-carbonate skarn, diopside skarn, and an ophicalcite rock. The latter two are from immediately next to the phlogopite-carbonate skarn. This relationship suggests that syenite might have been the source of REE-rich fluids which flowed through a more permeable layer, now represented by the phlogopite-carbonate skarn. Fluids then infiltrated outward from this horizon into other less permeable sedimentary rocks.

CONCLUSIONS

REE patterns for the Guano area sediments, skarn rocks, and syenite dykes are similar, although their magnitudes are quite variable. They imply a crustal origin for the REE, but the data do not distinguish clearly between a sedimentary or an igneous source.

REE data for the syenite, N6, is unusual. The sample analyzed shows very high total REE, but it is highly altered. Dykes of syenite within the skarn have patterns similar to the Guano average and very low total REE.

Surface and petrological relationships indicate strongly that the syenite was responsible for the skarn forming fluids, and probably coincidentally for the REE concentration.

A definitive origin for the REE in the Guano skarn cannot be defended with the data available. Understanding the mechanism for their concentration hinges on the distinction between a sedimentary and versus an igneous origin. Such distinctions cannot be made with certainty until the origin of the REE is more clearly understood.

ACKNOWLEDGEMENTS

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BIBLIOGRAPHY

Deer, W.A., Howie, R.A., and Zussman, J., 1966, An Introduction to the Rock-Forming Minerals: Longman Group, Ltd., London.

Goldberg, E.D., Koide, M., Schmitt, R.A., and Smith, R.H., 1963, Rare earth distributions in the marine environment: J. Geophys. Res. 68, p. 4209-4217.

Haskin, L.A., Frey, F.A., and Wildeman, T.R., 1968, Relative and absolute terrestrial abundance of the rare earths in Origin and Distribution of the elements, L.H. Ahrens, Ed., Intern. Ser. Monographs Earth Sci. 30, p. 889-912.

Haskin, M.A., and Haskin, L.A., 1966, Rare earths in European shales: a redetermination: Science 154, p. 507-509.

Herrmann, A.G., 1968, Die Verteilung der Lanthaniden in basaltischen Gesteinen: Contr. Mineral. and Petrol. 17, p. 275-314.

Herrmann, A.G., 1971, The Lanthanides in Wedepohl, K.H., ed., Handbook of Geochemistry , v. II-4 39, p. 57-71.

Moeller, T., 1963, The Chemistry of the Lanthanides: Reinhold Publishing Corporation, New York, 117 p.

Nance, W.B., and Taylor, S.R., 1976, Rare earth element patterns and crustal evolution - I. Australian post-Archean sedimentary rocks: Geoch. et Cosmoch. Acta v. 40, p. 1539-1551.

Overstreet, W.C., 1967, The Geological Occurrence of Monazite: U.S. Geol. Surv. Prof. Paper 530, 327 p.

Rose, E.R., 1975, A field test for rare earth elements: Geol. Soc. Canada Spec. Paper 75-16.

Sinclair, A.J., 1976, Applications of probability graphs in mineral exploration: Assoc. of Expl. Geoch. Spec. Vol. No. 4.

Tempelman-Kluit, D.J., 1977, Stratigraphic and structural relations between the Selwyn Basin, Pelly-Cassiar Platform, and Yukon Crystalline Terrane in the Pelly Mountains, Yukon: Geol. Surv. Can. Paper 77-1A, p. 223-227.

Towell, D.G., Winchester, J.W., and Volkofsky Spirn, R.V., 1965, Rare earth distributions in some rocks and associated minerals of the batholith of Southern California: Jour. Geophys. Res. 70, p. 3485-3496.

Whittle, A.W.G., 1960, contact mineralisation phenomena at the Mary Kathleen Uranium Deposit: N. Jb. Miner., Abh. v. 94, p. 798-830.